2,000 >10,000 6 Bi AA, 2,000 Ba, >100 Cd AA, 76 Sb AA, >1,000 Sn.

1,000 >20,000 >10,000 28 Bi AA, 200 Cd, 7 Mo, >1,000 Sb AA, 20 Sn.

500 >20,000 >10,000 1,000 Mn, 150 Sb, 15 Sn.

0 20,000 10,000 10,000 Sb,53 Bi,200 Cd.

N >5,000 Ba, 50 Mo.

N 300 B, 2000 Ba, 10 Sn.

500 >5,000 Mn,100 Ni, 10 Mo.

000 >1,000 Sn, >2000 B, 100 Bi, 300 Cd, 100 Sb.

200 3,000 Ba, 10 Mo.

200 >10,000 Sb.

100 100 Sb, 100 Sn 100 100 Sb, 20 Sn.

N 500 Mo.

N 3,000 Ba, 30 Mo.

Table 1. Geochemical signature of altered and mineralized rocks in the Healy Quadrangle, Alaska [Values in parts per million. N, not detected; --, not analysed; AA, analysed by atomic absorption spectrophotometry; all others by semiquantitative emission spectrography; Au, gold; B, boron; Ba, barium;

Bi, bismuth; Cd, cadmium; Co, cobalt; Cu, copper; La, lanthanum; Mn, manganese; Mo, molybdenum; Ni, nickel; Sb, antimony; Sn, tin; V, vanadium]

Kuroko massive sulfide

Kuroko massive sulfide

--Polymetallic replacement(?)

Low-sulfide Au-quartz vein

Arsenopyrite, galena, and sphalerite---

Massive galena and sphalerite

Quartz vein containing arsenopyrite-

Quartz vein containing fine pyrite--

Tertiary volcanic rocks

Graphitic quartzite--

Iron-stained graphitic quartzit

Propylitized granodiorite-Graphitic phyllite-----Copper-stained gossan---

Tourmaline greisen------Breccia containing sulfides--

Quartz vein in black phyllite--Veins in altered granitic rocks

Veins in altered granitic rocks-

Strong pyrite veinlets in phyllite-

Quartz-calcite vein in phyllite-

Carbonate alteration in phyllite Disseminated pyrite in diorite--

Carbonate alteration in felsic volcanics-Disseminated pyrite in metagraywacke-

artz-pyrite vein in metasedimentary rock

HE1066R iron-stained argillite-

Massive galena, sphalerite, and arsenopyrite-

11 Healy Creek HE1070R Pyritic schist containing sphalerite-

12 Anderson Mountain HE1068R Massive pyrrhotite----

Sec 30, T16S, R3E 80Cx106 Iron-stained shear zone--

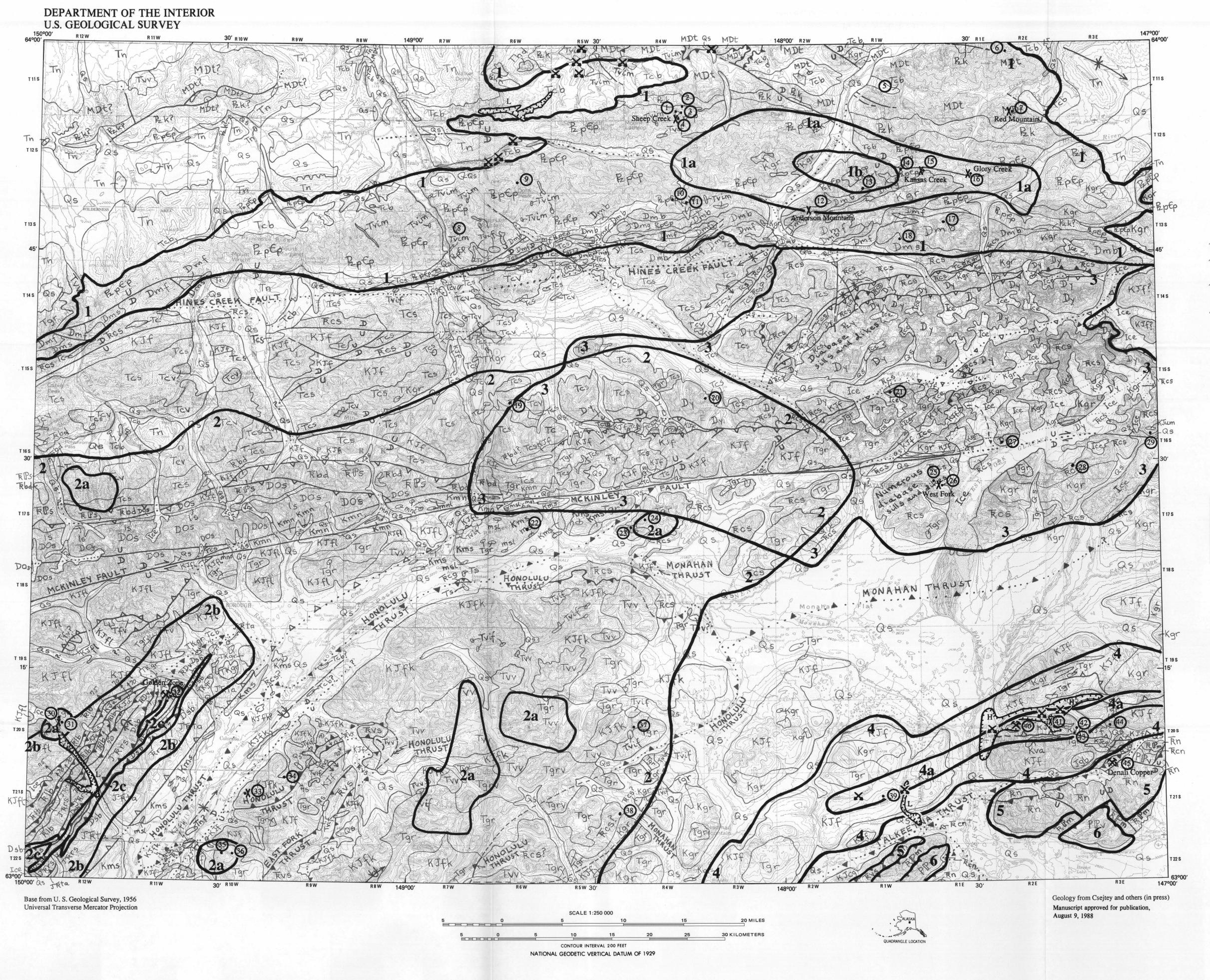
13 Virginia Creek

West Fork Glacier

Lucky Top Black Creek Pass Lake

ORDO VICIAN

Probable deposit type Gold Silver Arsenic Copper Lead Zinc



This report, as part of the Alaska Mineral Resource Assessment Program AMRAP), assesses the lode metalliferous mineral resources of the Healy 1 quadrangle, Alaska, on the basis of deposit types that occur or may occu n the area. Included in this report is a study by Warren Yeend that assesses the placer gold resources of the quadrangle. Mines, prospects; and mineral occurrences in the quadrangle are described below, and the geochemical signature of mineralized and altered rocks from on the map, are permissive for the occurrence of one or more deposit types These tracts are based mainly on geology (Csejtey and others, 1986; in press), geochemistry (Light and others, 1987; King and others, in press; Tripp and thers, in press), and distribution of mineral deposits and occurrence Capps, 1919, 1940; Clark and Cobb, 1972). The map also shows the areas of placer gold resources discussed by Warren Yeend. The criteria used to delineate each tract are shown in table 2. For some deposit types, estimates of number of undiscovered deposits are presented. These estimates along with tonnage-grade estimates published in Cox and Singer (1986) provide the most description currently possible of the undiscovered mineral resources of the Healy quadrangle.

The Healy quadrangle is underlain by a wide variety of sedimentary, volcanic, metamorphic, and plutonic rocks, which range in age from cambrian(?) to Quaternary. Fifty-five map units are shown on the Talkeetna superterrane with and onto the Yukon-Tanana and Nixon Fork terra of the ancient North American continent. During the accretionary process the large flysch basin that separated the converging continents collapsed, but late stages of this accretionary orogeny were accompanied by the intrusions of dominantly tonalitic plutons and subordinate mafic hypabyssal volcanic rocks and by extensive regional metamorphism. possibly early Tertiary plutonic and hypabyssal volcanic rocks, extensive Paleocene to Holocene terrestrial sedimentary rocks, and substantial amounts

of Paleocene to Oligocene subaerial and hypabyssal felsic to mafic volcanic rocks and a suite of dominantly felsic epizonal plutonic rocks of the same age sequence of Lanphere and Reed (1985) are part of the early Tertiary granitic The Yukon-Tanana terrane mainly consists of clastic marine Precambrian(?) to Early Mississippian age and a thick sequence of Upper thick Ordovician to Middle Devonian sequence of marine clastic, in part is spatially associated with the Nixon Fork rocks. The Wrangellia terrane of the Talkeetna superterrane is represented by slightly metamorphosed, dominantly marine mafic volcanic and volcaniclastic rocks and subordinate age. Near the southwest corner of the quadrangle, in the Chulitna mining district, an allochthonous, internally faulted klippe is present that contains Devonian to Early Cretaceous. These rocks include an ophiolitic sequence that

Some concentrations of metallic minerals, such as kuroko massive sulfides and basaltic copper, were formed early in the history of the Yukon-Tanana terrane and the Talkeetna superterrane, respectively. Other types of deposits plutonic rocks, and the areas favorable for their occurrences transcend SUMMARY OF GEOCHEMISTRY As noted by Light and others (in press), the geochemistry of the Healy silver, and zinc in stream sediments and (2)

quadrangle is dominated by two provinces: (1) a northeastern province containing tin in anomalous amounts (less than 1000 ppm) in heavy-miner occurs in a broad zone that extends from the southwest to northeast corners of rocks of the Yukon-Tanana terrane and probably derives from minerals related to kuroko massive sulfide deposits. The southwestern province corresponds to distribution of granitic intrusive rocks of the McKinley sequence Lanphere and Reed, 1985) and may represent tin greisen and vein deposits and dikes of Tertiary age and may be related to polymetallic veins and simp the northeast, complex anomalies result that are difficult to interpret. Individual anomalies related to individual prospects and occurrences are

AEROMAGNETIC FEATURES

anomalies that extends over most of the quadrangle and (2) a "noisy" provinc of high amplitude, short-wavelength northeast-trending features that occupie the southeastern corner. The boundary between these regions correspond magnetic anomalies in the northern area may indicate deep-seated plutons Some of these anomalies have straight edges that suggest fault boundarie Elongate magnetic highs in the southeastern area suggest tabular bodies o high magnetic susceptibility. These reflect basalt flows and intrusions o Triassic age belonging to the Wrangellia terrane. Superimposed on the "quiet wavelength, low-amplitude "birds eye" magnetic anomalies. This is a typic pattern for mafic volcanic rocks and probably represents flows and volcan: centers of Tertiary age. Individual magnetic anomalies related to mineral

Our study assesses the potential for copper, lead, zinc, and precious metals in kuroko massive sulfide, skarn, and replacement deposits; tin greissen deposits; gold and silver in polymetallic veins and pipes and imple antimony deposits; chromium in podiform chromite; molybdenum in lowfluorine porphyry molybdenum deposits; gold in low-sulfide gold-quartz veins; and copper in basaltic copper deposits.

KUROKO MASSIVE SULFIDE DEPOSITS Kuroko deposits (reviewed by Singer, 1986) occur with marine volcanic rocks of intermediate to felsic composition in many parts of the world. They re composed of stratiform lenses and layers of massive pyrite, chalcopyrite, Two occurrences in the Healy quadrangle are classified as kuroko-type deposits. At Red Mountain (loc. 7), massive sulfide layers are exposed on the lanks of a syncline in felsic metavolcanic rocks of the Mystic Creek Member of the Totatlanika Schist. The layers contain abundant pyrite and lesser amounts of sphalerite, galena, and chalcopyrite. The deposits are estimated to contain 1.12 million tonnes of ore of 0.15 percent copper, 2.5 percent

(Nokleberg and others, 1987). At Anderson Mountain (loc. 12), massive sulfide yers in metamorphosed felsic tuff and calcareous clastic rocks of Precambrian(?) and Paleozoic age contain pyrite, chalcopyrite, galena, sphalerite, enargite, and arsenopyrite. The layers have irregular footwalls eralization is absent (Nokleberg and others, in press). Volcanogenic massive sulfide mineralization also occurs at Sheep Creek, Snow Mountain mucn, nealy Creek, Virginia creek, West rork Little Delta River, and the rirque prospect (locs. 4, 6, 11, 13, 17, and 18, respectively). The extent of mineralization at these localities is not well known, and no resource Areas permissive for undiscovered kuroko deposits are tracts 1 and 6 (see map). The main criterion for delineation of these tracts (table 2) is the heir metamorphic equivalents. In tract 1 this delineation is reinforced by widespread stream-sediment anomalies in silver, gold, barium, copper, lead and zinc (King and others, in press). In tract 6 a strong geochemical

ignature is not present, but delineation is otherwise supported by the fact tract compose the lower part of the Wrangellia terrane of the Talkeetna superterrane. Rocks of similar age and terrane association are known to contain kuroko deposits in many places in southeastern Alaska and Vancouver percent chance that two or more, and a 10 percent chance that four or more undiscovered deposits of the kuroko type occur in the Healy quadrangle. These e grade-tonnage model for kuroko deposits by Singer and Mosier (1986): 9 percent of the deposits would have tonnages of 1.5 million tonnes or more lian grades for kuroko deposits are 1.3 percent copper, 2 percent zinc, and 16 and 1.3 ppm gold and silver, respectively. The Red Mountain deposit is t included in this estimate because it is considered to be a discovered and model. The Anderson Mountain occurrence is unevaluated and included in the estimate of undiscovered deposits.

TIN GREISEN AND OTHER TIN DEPOSITS According to Reed's (1986) general model, tin greisen deposits contain disseminated cassiterite and cassiterite-bearing veinlets, stockworks, lenses, topaz-fluorite. Tin veins are commonly associated with greisens, and, in areas of carbonate rocks, tin skarn and replacement tin deposits may occur. All of these deposits are commonly associated with granitic rocks that have high values of lithium, beryllium, niobium, thorium, and rare-earth elements. In the Healy quadrangle, tin greisen mineralization has been noted at hio Creek, (loc. 31). A stock of medium-grained sodic granite (albiteoligoclase, quartz K-feldspar, and muscovite) contains abundant arsenopyrite d tourmaline in veinlets and disseminations (Hawley and Clark, 1974). Samples from this greisen contain more than 1,000 ppm tin and anomalous deposit on Coal Creek, a few kilometers south of the quadrangle boundary, is

estimated to contain 5 million tonnes of material that has more than 0.5 may also occur in these tracts, and, in the northeast part of tract 2, ti skarn and replacement deposits may occur where calcareous sedimentary rocks o courmaline-bearing granitic rocks and a drainage basin in which cassiterite 2 is delineated on the basis of (1) widespread outcrops of 57- to 60-Ma biotite granite correlated with the McKinley sequence of Lanphere and Reed (1985) and (2) the widespread anomalies of lithium, beryllium, niobium, thorium, and rare-earth elements in stream sediments derived from these granites (King and others, in press). The area effected by these intrusions is broad and diffuse and appears to cross major faults, including terrane boundaries, without offset. The McKinley sequence is known to host ti nineralization in the Talkeetna quadrangle (Reed and others, 1978). Th presence of tin greisen deposits is suggested by numerous anomalies of tin, silver, copper, arsenic, bismuth, and other metals. Tracts labeled 2a enclose stream drainage basins in which cassiterite and fluorite were found in panned concentrates of stream sediment and are believed to have a higher chance for

that five or more undiscovered tin greisen deposits occur in the quadrangle. derived by Menzie and Reed (1986): 90 percent of the deposits would have million tonnes. The median of the average grade would be 0.28 percent tin. Because no subsurface evaluation has been done at Ohio Creek, this occurrence is considered to be one of the undiscovered deposits in this estimate. A class of deposits known as polymetallic veins were described by Cox

(1986a) as quartz-carbonate veins containing silver and gold in association with pyrite, arsenopyrite, and stibnite and base-metal sulfides and sulfointermediate to felsic composition and may be found in host rocks of any composition. The veins have an open, vuggy structure, typical of epithermal deposits, and grade from simple veins to stockworks to pipe-like breccia-In the Healy quadrangle, polymetallic veins and pipes are exemplified by deposits in the Chulitna mining district and at Glory Creek. At the Golden Zone mine in the Chulitna district (loc. 27) (Hawley and Clark, 1974; nd quartz fill breccia voids and fractures in the shattered interior part of piotite-quartz diorite porphyry plug of Late Cretaceous age. Sericitecarbonate alteration is associated with the ore. High-grade ore produced from this deposit in 1941 (the only year of production) averaged 28 g/t gold, 155 g/t silver, and 1.2 percent copper, and a composite mill-test sample was reported to contain 7 g/t gold and 39 g/t silver (Mulligan and others 1967)

No tonnage estimate is available for the deposit. The Chulitna mining district comprises numerous northeast-striking polymetallic veins that cut Mesozoic clastic sedimentary rocks. These veins contain arsenopyrite, pyrite, and quartz and lesser amounts of pyrrhotite, chalcopyrite, sphalerite, galena, and stibnite. Although many of these veins contain signficant values in gold and silver, no record of production from them is available. At the Glory Creek prospect (loc. 16), several quartz veins as much as 30 cm in width and striking northeast have border zones rich in arsenopyrite and pyrite and younger veinlets of sphalerite, galena, and fine-grained stibnite. Tracts la and 2b were delineated by the distribution of the prospects described above and by stream-sediment samples anomalous in silver, arsenic gold, copper, lead, zinc, and, locally, antimony and bismuth. These tracts are favorable for the occurrence of polymetallic veins. A broader area is made. Typically this deposit type tends to be less than 200,000 tonnes in

SIMPLE ANTIMONY DEPOSITS disseminations in or adjacent to sheared fault zones (Bliss and Orris, 1986). These deposits are mineralogically simple, and stibnite is the only megascopically visible mineral. Antimony Creek (loc. 33). At Kansas Creek, a small deposit of stibnite that forms a zone as much as 2 m in width occurs with quartz veins in metavolcan rocks. Joesting (1943) estimated that 200 tons of ore is recoverable, b that hand sorting would be required to produce a shipping ore of 50 percent antimony. The Antimony Creek occurrence is composed of stibnite in dark-gray schist in exploration pits that extend N. 20° E. for about 10 m. Samples of stibnite-rich material contain 6 g/t gold (Hawley and others, 1968) nd, thus, tracts la and 2b can be considered favorable for both of them. Fault zones in tract 2 are also favorable for their occurrence. Not enough information is available to delineate a broader permissive area or to estimate the number of undiscovered deposits.

Podiform chromite deposits (reviewed by Albers, 1986) are irregular masses of chromitite in the dunite and peridotite of ophiolite assemblages permissive for their occurrence underlie parts of the Chulitna mining distric in the southwest corner of the quadrangle. These rocks are delineated as tract 2c. Because of the small size of the outcrop area of these rocks, we estimate that there is less than a 10 percent chance that one or more podiform chromite deposits that are consistent with the grade-tonnage model of Singer and Page (1986) occur in the Healy quadrangle.

Copper skarn, lead-zinc skarn, and iron skarn deposits as reviewed in Cox and Singer (1986, p. 86-97) contain base-metal sulfides and (or) iron oxides in contact-metamorphic calculate gangue. They are found near contacts between igneous intrusions and calcareous sedimentary rocks. Examples of copper skarn, lead-zinc skarn, and polymetallic replacement deposits have no been identified in the Healy quadrangle. Skarn-type alteration with pyrrhotite was noted at locality 21 on the south wall of the Yanert Glacier alley, and a zone of intense malachite—azurite mineralization in graphit Susitna River 10 km north of the toe of the West Fork Glacier (loc. 26). mineralized zone at West Fork is about 10 m wide and trends northeast. lacks the calcsilicate minerals typical of skarns and is difficult to class because of intense weathering and lack of subsurface data. The presence of zinc and silver in analyses of the copper-rich gossan suggests that it may be comparable to the polymetallic replacement model of Morris (1986) Polymetallic replacement deposits are pods, blanket-like bodies, and pipes of massive galena, sphalerite, and other minerals in calcareous rocks near igneous intrusions. They commonly occur farther away from igneous contacts than skarn deposits but are closely related to them in many places. Tract 3, permissive for the occurrence of skarn and replacement deposits granodiorite and tonalite of Tertiary age and calcareous sedimentary rocks of riassic age and (2) the widespread stream-sediment anomalies in copper, lea zinc, silver, molybdenum, tungsten, and arsenic (King and others, in press)

which stream-drainage basins anomalous in copper, molybenum, and tungsten form a central cluster surrounded by basins anomalous in silver, arsenic, lead, and zinc, suggests that hydrothermal circulation systems existed around intrusive centers and may have concentrated metals in deposits. Because of the lack of estimate numbers of undiscovered skarn deposits and polymetallic replacemen

PORPHYRY MOLYBDENUM (LOW-FLUORINE) DEPOSITS In general, deposits of this type are described as stockworks of quartz and molybdenite, pyrite, and minor scheelite and chalcopyrite in altered hypabyssal intrusions of granodiorite or tonalite (Theodore, 1986). Scar information exists about deposits of this type in the Healy quadrangle. I 21 S., R. 1 W., D.L. Stevens (oral commun., 1979) reported molybdenite veins in intrusive rocks in a drill hole. We noted quartz veins in sericiti molybdenum (loc. 39), and stream-sediment samples nearby contain anomalous amounts of molybdenum (King and others, in press). We delineated tract 4 as permissive for porphyry molybdenum deposits based on the above observations and the distribution of plutonic rocks of Tertiary age. No estimate of the number of undisovered deposits was made.

Low-sulfide gold-quartz vein deposits contain native gold in massive and persistant quartz veins, minor amounts of pyrite, and traces of other sulfides and are found in regionally metamorphosed volcanic rocks and volcanogen quadrangle, these deposits are represented by veins cutting Cretace greenschist-facies metagraywacke and Tertiary granitic plutons in the Valdez Creek mining district (Smith, 1981). The most extensive underground workings in this district comprise the Timberline mine (loc. 40), which produced an ankerite, and small amounts of pyrite, pyrrhotite, arsenopyrite, galena sphalerite, and chalcopyrite. Trace amounts of hessite and goldfieldite a associated with these veins. The veins have recorded assays ranging from 0.18 to 123 g/t gold. Overall tonnage is unknown, but one vein was estimated to

Low-sulfide gold-quartz deposits are also found along the south side of Valdez Creek in an easterly-trending belt (locs. 41-43). Smith (1981) showed that individual veins in this belt strike N. 80° W. and N. 50° to 80° E. in a conjugate relation, and that left lateral movement on the northwest-striking zone of greenschist-facies metamorphic rocks that lie between the Talkeetna thrust fault and higher grade metamorphic rocks to the north. Tract 4 wa delineated as permissive for low-sulfide gold-quartz veins on the basis o retaceous greenschist-facies metagraywacke and Tertiary granitic plutons ract 4a is considered more favorable for deposits because of the presence gold mines and prospects and gold anomalies in stream sediments (King and others, in press). Because of the high level of past exploration for gold in nis area, we assign only a 50 percent chance that one undiscovered deposi nd a 10 percent chance that two or more undiscovered deposits occur in this rea. Ninety percent of these deposits would have a tonnage of 1,000 tonnes or more, and 50 percent would have a tonnage of 30,000 tonnes or more Median gold grades expected would be 16 ppm (Bliss, 1986). The Timberline

The term basaltic copper (Cox, 1986b) refers to a diverse group of copper sandstone and massive copper ores in carbonate rocks overlying thick basal 5) is believed to be an example of this type. The Denali mine is developed on the largest of several stratiform bodies of rythmically layered fine th black phyllite, tuff, and thin beds of limestone (Stevens 1971; Seraphin . The deposits lie at or near the upper contact of the Nikola Greenstone, and the intercalated limestone beds contain $\underline{\text{Halobia}}$ similar to $\underline{\text{H.}}$ superba, whose age range is late Karnian to early Norian (N.J. Silberling, written commun., 1980). These rocks are part of the Wrangellia terrane of the The mineralogy of the deposit is simple: chalcopyrite predominantes as extremely small grains separated from each other by carbonaceous phyllite

races of bornite are also present. Tonnage and grade of the Denali deposit have not been published, but, based on information available (Stevens, 1 and Seraphim, 1975), it is likely that the largest mineralized body contains between 100,000 and 200,000 tons of ore that contain between 2 and 5 percent The rythmically layered ores of the Denali deposit are quite unlike any described in the literature; thus, classification of the deposit is difficult. Smith (1981) and Nokleberg and others (1987) classify the deposit as Besshi type based on its association with mafic flows in a marine environment and on its stratiform nature. Denali differs from the Besshi type, however, in its low pyrite content. Cox (1986b) has grouped the Denal leposit with the basaltic copper type, such as Kennecott, Alaska, that lies at the top of a thick copper-rich basalt unit, in this case, the Nikola Greenstone. The Nikolai in the Healy quadrangle and in the McCarthy quadrangle near Kennecott, Alaska, has a high copper content and contains many small copper occurrences (McKevett and Singer, 1977). Copper was presumably leached from the basalt and deposited in overlying limestone at Kennecott, and Tract 5, permissive for the occurrence of basaltic copper deposits i delineated on the basis of the extent of the Nikolai Greenstone and overlying sedimentary rocks of Triassic age. No estimate for number of undiscovered

copper deposits was made for this tract. This study has assessed the possibility of undiscovered deposits of many different types in the Healy quadrangle. The relative importance of these types depends on the degree of certainty of undiscovered deposits for each type and on the probable value of a deposit, given its discovery. Kurok massive sulfide deposits in tract 1 rank high in both factors and are the most tant mineral resource in the quadrangle. Tin greisen deposits in tract lb and 2 would have a high value both in monetary terms and in relief o lependency on imports. These deposits, however, have a greater uncertainty iscovery and are of secondary importance. Low-sulfide gold-quartz veins i ract 4 would have a moderate value if discovered, but the chance of a new leposit is low considering the history of exploration in the area. The deposit type ranks third in importance. Porphyry molybdenum (low-fluorine leposits, skarn, and polymetallic replacement rank low in importance because neir occurrence is unlikely. Polymetallic veins and simple antimony are present in the quadrangle, and undiscovered deposits are likely to exist, but their value, if discovered, would be low. Podiform chromite ranks low in both value and likelihood of occurrence. The authors wish to thank Dr. Donald L. Stevens, who showed us the Denali

deposit in 1979 and pointed out numerous prospects and occurrences in the quadrangle, and John H.C. Bain of the Australian Bureau of Mineral Resources who helped with the field study in 1981. Helpful suggestions were contributed by Donald A. Singer and Warren J. Nokelberg. PLACER GOLD IN THE HEALY QUADRANGLE Perhaps as much as 60,000 ounces of placer gold has been produced from mining districts of the Healy quadrangle. The production before 1960 was

nostly from the Valdez Creek mining district, although some was from th

district is just outside the north border of the Healy quadrangle. Estimated

unmined resources seem to be greater in the Valdez Creek area, where the

greater amount of mining is currently taking place.

Gold was first discovered in the Bonnifield district in 1903 by prospectors who came from the mining areas in and around Fairbanks. As many as 50 to 100 men were prospecting and mining in the district during the early years. Only the southernmost part of the district lies within the Hea quadrangle. Placer gold has been mined on Healy Creek and the headwaters o n Healy Creek and its tributaries was initiated in 1913 when gold was derive from the lower 500 feet of the Nenana Gravel. Shotlike-size gold nuggets and flattened flakes 3 to 10 mm in diameter were mined from Home Creek, cributary of Healy Creek (Maddren, 1918).

Although small amounts of gold have been found on Shotgun Creek and other streams in the southwest part of the quadrangle, by far the bulk of placer gold mined in the quadrangle has come from the Valdez Creek area near the southeast corner of the quadrangle. Gold was discovered here on August 15 1903, by Peter Monahan, J.S. Smith, J.M. Johnson, and J.C. Clarkson. Valde reek was named after the town of Valdez from which these enterprising dividuals had embarked on their prospecting tour. Much of the early production came from the immediate vicinity of the village of Denali, and as many as 150 separate mines produced placer gold. Most of the original mining was done with pick, shovel, and sluice box from Valdez Creek. Hydraul ining and "booming" were methods adopted when adequate water was available om 1913 to 1924. During this period, mining was active in the area known as on the south side of Valdez Creek. In 1931, about 15 placer mines at Denali and seven more along Valdez Creek were in operation (Ross, 1933).

Several types of placer gold deposits are present within the Healy

quadrangle. Modern stream gravels have accounted for most of the production. however, buried Pleistocene channel gravel in the Valdez Creek area yielded considerable placer gold and probably still represents a moderate unmined resource here. Of lesser importance are alluvial bench gravel deposit present along some of the modern streams and rivers and Tertiary gravels of large volume, but low unit value. VALDEZ CREEK DISTRICT Pleistocene alluvial gravel in buried channels (Tuck, 1938). The modern

Placer gold has been mined from modern gravels within the flood plain and on benches adjacent to Valdez Creek and its tributaries, as well as from gravels, most of which have been mined, are composed of boulders as much as 2 in diameter that consist of local types of bedrock: argillite, graywacke, llite, and diorite. In 1980, the coarse gold being mined from the gravels n Valdez Creek was characterized as being of oatmeal-size fragments, very flattened and round edged. Colors of gold fragments varied from lemon yellow to rich golden brown, to reddish brown (iron stained) (Yeend, 1984). The buried Tammany Channel was originally mined by tunneling. The bulk of the gold was obtained from the lower 2 m of gravel, although fine gold was found throughout the alluvial section. The channel where mined is a gorge 45 to 60deep and at least 90 m across at the top. The upper part of the channel and e surrounding bedrock bench is mantled with a blanket of glacial drift as much as 23 m thick. As much as 15 m of the buried channel gravel may be goldbearing (Yeend, 1984). Source of the gold in Valdez Creek is most likely the low-sulfide gold-quartz veins that cut the Cretaceous graywacke deposits.

Bonnifield placer mining district. The headwaters of the Totatlanika River, Moose Creek, Healy, Dry, and Portage Creeks have been mined for placer gold at various times during the last 80 years. Most of the deposits are stream placers, although gravel benches as much as 7 m above the streams have been and platinum-gold metals (Maddren, 1918). Capps (1912) pointed out that th workable placers in this northern district have all been found in areas that drain terrain presently or originally covered by the upper Tertiary Nenana from these gravels has produced most of the present placer deposits, although some gold may have been contained in the lower Tertiary beds and have been reconcentrated..." Similarly, Maddren (1918) felt that a source for much of the placer gold mined here was derived from the lower 150 m of the Nenana avel. In the summer of 1981, I obtained two small gold flakes from a large pan of gravel taken from the contact between the Lignite Creek Formation and the overlying Nenana Gravel near where the main highway to Fairbanks crosses Panguingue Creek. In the Mount Hayes quadrangle, directly east of the Healy

CURRENT PLACER MINING One of the largest placer mines in the state in terms of recent production is located in the Valdez Creek area. Approximately 30,000 ounces of gold was produced there in 1985 by SUM Resources of Canada, one of several nt-venture partners. Production is from extensions of the buried Tammany nannel. Drilling programs have identified buried channels along several nousand feet of strike length, indicating several more years of production (Sims and Green, 1986). Smith (1970) conducted a seismic-refraction survey to locate buried incised channels in the Valdez Creek area. He identified a deposit described as the Denali bench gravels that contains more than 35 million cubic yards of auriferous gravels that has values ranging from \$5 to Smaller placer mines have been active in recent years on Valdez Creek itself and several of its tributaries. Mining operations on Totatlanika and Portage Creek, in the northeast corner of the quadrangle, are small scale and generally employ two to five people per operation. Areas of high and low potential for placer gold (see map) were delineated on the basis of sampling and analysis of part of the production. The area of

high potential is believed to contain at least 50 million cubic yards of

gravel that will average at least \$5/yd3; other gravel in the area will

average less than \$5/yd3. Within the areas of low potential small zone:

within the gravel could contain gold values of more than $$1.80/yd^3$. No attempt has been made to estimate the cubic yards of gravel available within

the areas of low potential because of their great variability and the lack of

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CORRELATION OF MAP UNITS

ALL AREAS OF QUADRANGLE

SOUTHWESTERN AND WEST-CENTRAL AREAS OF QUADRANGLE SEDIMENTARY AND VOLCANIC ROCKS;

rocks of each column occur in separate fault blocks

Rocks of Nixon Flysch and rocks unknown ter- Fork of unknown ter-

> Is Middle Devonian DOs to Ordovician

SEDIMENTARY AND VOLCANIC ROCKS

NORTHERN, EASTERN, AND SOUTH-CENTRAL

AREAS OF QUADRANGLE

associated rocks (Wrangellia terrane

SEDIMENTARY AND VOLCANIC ROCKS;

rocks of each column occur in separate fault blocks

terrane

TABLE 2. Criteria used to delineate tracts and assess mineral resources in the Healy quadrangle, Alaska
[Elements are gold, Au; chromium, Cr; manganese, Mn; antimony, Sb; arsenic, As; barium, Ba; beryllium, Be; bismuth, Bi; boron, B; copper, Cu; iron, Fe; lithium, Li; lead, Pb; molybdenum, Mo; nickel, Ni; niobium, Nb; rare-earth elements, REE; thorium, Th; tin, Sn; tungsten, W; zinc, Zn] Geochemical anomalies and minerals in stream sediments in the tract. () indicates weakl permissive for deposit anomalous Elements in Minerals in Elements in MINERAL RESOURCE SYMBOLS Talkeetna superterrane concentrate concentrate samples samples (includes Wrangellia terrane) Kuroko massive Cu + Zn \pm Pb-bearing Dmf-Felsic metavolcanic Ag, As, Au, Arsenopyrite Ag, B, Ba, Metavolcanic, metavolcaniclastic, and subordinate Barite Cu, Mo, Chalcopyrite Pb, Zn. sulfides (tract massive sulfide rocks, ranging from rhyolite Sheep Creek (loc 4) metasedimentary rocks (Late Triassic; late Norian)--Pb, W, Zn, includes tracts la Anderson Mountain Prospect and mineral occurrence Marine basalt, tuff, slate, and diabase sills. Red Mountain (loc 7), Chitistone and Nizina Limestones, undivided (Late MDt-Metavolcanic and meta-Triassic; early Norian and late Karnian) volcaniclastic rocks, both felsic and mafic in composition, and subordinate black peltic Nikolai Greenstone (Late and (or) Middle Triassic)--Mainly subaerial flows of amygdaloidal basalt Pzp p-Pelitic and quartzose schist contains local interbeds of chlorite Metasedimentary rocks sequence (Middle Triassic schist that suggest tuffs or flows Mineral-resource tract--See table 2 to Late Pennsylvanian?)--Black argillite, thin beds of volcanic breccia and sandstone, and limestone overlain by veins with base-Deposits are probably related thin-bedded chert. Sills and dikes of gabbro to small intrusions of Tertiary Pb, W. Zn. Chalcopyrite Mo, Pb, Zn metal sulfides Area of placer gold resources-related to hypaage not shown on map. Andesitic volcanic rocks (Early Permian? and H, high potential; L, low potential Pennsylvanian)--Volcanic flows and breccias, probably marine PLUTONIC ROCKS None diagnostic---- Same-----Granitic rocks (Late and (or) Early Cretaceous)--Pzp p-Pelitic and quartzose Mainly tonalite, quartz diorite, and granodiorite, **DESCRIPTION OF MAP UNITS** generally well foliated Tourmaline-bearing granite (Late or Early Cretaceous) ALL AREAS OF QUADRANGLE stockwork veinlets for buried non-SEDIMENTARY AND VOLCANIC ROCKS magnetic intru-Ultramafic rocks (Early Cretaceous or Jurassic)-Plagioclase-bearing peridotite Surficial deposits (Quaternary) Polymetallic veins See above------ Fault zone in Kansas Creek----- None known----- None diagnostic----Alkali gabbro (Late Jurassic) See above----- Pzp p-Pelitic and quartzose None known----- None diagnostic--- ------Hornblende dacite (Pliocene) Metagabbro (Late Devonian?) Nenana Gravel (Pliocene and Miocene)-includes tracts siterite and Sn Poorly consolidated conglomerate and sandstone 2a, b, and c below). stockwork veinlets 57 to 60 Ma, contain between Jack River Pb, Sn, W, Cassiterite 31) and Coal Creek Chalcopyrite SOUTHWESTERN AND WEST-CENTRAL AREAS OF QUADRANGLE Coal-bearing rocks (Miocene to Eocene)--Healy quadrangle. Mainly siltstone and shale with subbituminous REE and Th ano-SEDIMENTARY AND VOLCANIC ROCKS malies derived coal and lignite Ohio Creek area (Chulitna district) Sedimentary rocks (Miocene? to Paleocene?)--Mainly poorly consolidated shale, sandstone, - Cassiterite and Tgr-Same as above T cs-Carbonaceous sequence o siltstone, and conglomerate Cretaceous and Late Jurassic) intercalated calcareous shale replacement of argillite, sandstone, siltstone Volcanic rocks (Oligocene to Paleocene)--Red and brown sedimentary rocks and basalt (Early and argillaceous limestone. Jurassic and Late Triassic)--Red sandstone, siltstone, Flows, pyroclastic rocks, and subvolcanic Includes numerous dikes and conglomerate, and basalt overlain by brown sandstone intrusions--Subaerial volcanic rocks and subordinate likes ranging in composition from basalt to rhyolite Sn replacement---- Cassiterite and T cs-Same as above------ None known----- None known-----Limestone and basalt sequence (Late Triassic; Norian?) tabular replacement Felsic subvolcanic intrusive rocks-Mainly dikes of rhyolite and dacite Red beds (Late Triassic)--Red sandstone, siltstone, Mafic subvolcanic intrusive rocks--Mainly dikes and conglomerate of basalt and subordinate andesite Volcanogenic and sedimentary rocks (Early Triassic ----- Same as Same as tract 2 Same as Fluviatile and volcanic rocks (Eocene?)to Late Devonian) -- Tuffaceous chert, mudstone, and Mainly conglomerate, sandstone, and siltbasalt breccia; flysch-like graywacke and mudstone; stone and a few thin flows of basaltic Dsb Serpentinite, basalt, chert, and gabbro (Late Devonian) Cantwell Formation (Paleocene)--Volcanic rocks subunit--Flows of andesite, basalt, Flysch and associated rocks Golden Zone deposit rhyolite, and dacite and pyroclastic felsic rocks Flysch sequence (Late Cretaceous to Late Jurassic) Sedimentary rocks-- Mainly conglomerate, sandstone and shale and a few thin coal beds and volcanic flows and tuffs Crystal tuff, argillite, chert, graywacke, and limestone (Late Jurassic to Late Triassic?) PLUTONIC ROCKS Sn greisen---- See tract 2a----- Tgr-Same as above-----Franitic rocks (Oligocene to Paleocene)--Mainly granite and granodiorite Rocks of unknown terrane affinity Podiform Dsb-Ophiolitic serpentine and Granitic and volcanic rocks, undivided (Oligocene Conglomerate and volcanic sandstone (Late Triassic; to Paleocene) -- Border zone between granitic rocks and Tertiary volcanic rocks small relative to Granitic and hypabyssal intrusive rocks 1.2-km flight-line. (Paleocene? and Late Cretaceous)--Mainly granodiorite Sedimentary rocks sequence (Middle Devonian to ranodiorite and tonalite (38 Ma). skarn on-Ordovician)-Black argillite and siltstone, massive replacement of Trcs-Same as above. of Revine Creek; near toe of West Fork Glacier; NORTHERN, EASTERN, AND SOUTH-CENTRAL AREAS OF QUADRANGLE limestone nea limestone (ls), thinly bedded limestone, and chert SEDIMENTARY AND VOLCANIC ROCKS southwest of toe of Yanert Glacier; cluster near Yukon-Tanana terrane Flysch and rocks of unknown terrane affinity near Dick Creek Rocks north of Hines Creek fault north of Yanert Flysch sequence (Early Cretaceous and Late Jurassic)-Fork; northeast Basaltic subvolcanic rocks (Late Cretaceous)-Same rocks as unit KJf in eastern and southern parts corner of tract 2 Mainly dike swarms Basalt, diabase, and subordinate sedimentary rocks Totatlanika Schist (Early Mississippian to (Late Triassic; Karnian and Norian) Middle Devonian)--Carbonaceous slate, phyllite replacement. and schist: metachert, quartz-orthoclase-sericite schis Flysch-like sedimentary rocks (Late Triassic to and augen gneiss, metavolcanic rocks Pennsylvanian)--Impure sandstone, siltstone, and Felsic metavolcanic rocks (Late Devonian)-limestone near shale; minor limestone and chert granitic intrusions Sn greisen----- See tract 1 above None-----Metabasalt and subordinate metasedimentary Melange south of McKinley fault (Late and (or) Early rocks (Late Devonian)-Greenschist, metabasalt, Polymetallic vein-- See tract la above Tgr and numerous dikes Cretaceous) -- Dark-gray flysch, cherty tuff, volcanic and carbonaceous phyllite Metasedimentary rocks (Late Devonian)-sandstone, and blocks of limestone (msl) Sericite schist, black slate, and chert Melange north of McKinley fault (Late and (or)Early Keevy Peak Formation (early Paleozoic) Cretaceous) -- Similar to unit Kms but contains in porphyry Mainly sericite schist, quartzite, arkosic recrystallized limestones (mnl) and ophiolitic rocks schist, and black schist and phyllite (mno), mainly serpentinite, basalt, and chert Pelitic and quartzose schist sequence (early Paleozoic and Precambrian?)--Quartz sericite None diagnostic---- Ag, As, Au, Chalcopyrite Au, B, Be,
Cu, Mo, Pb, Gold (Ag), (Cu)
(Sn), (W). (Arsenopyrite) (Mn), (Zn) Contact--Approximately located (carbonate) schist, quartzite, and black phyllite Lucky Hill prospects flysch-like rocks. Rocks south of Hines Creek fault in Valdez Creek Thrust fault -- Showing direction of dip of overturned minor pyrite, thrust fault. Dashed where inferred; dotted where Calcareous sedimentary rocks (Late Triassic; concealed. Sawteeth on upper plate middle? Norian to late Karnian) -- Locally High-angle reverse fault-- Dashed where inferred; metamorphosed, carbonaceous, calcareous shale and sandstone and sandy to silty limestone. dotted where concealed. Sawteeth on upper Area especially favor- ------- Area especially ------Low-sulfide gold- Same as above----- Same as above----ncludes sills and dikes of gabbro able because of numerous Yanert Fork sequence (Late Devonian)--Fault-Dashed where inferred; dotted where Carbonaceous siliceous mudstone, slate, phyllite, and concealed. Where displacement known, U, upthrown schist; impure quartzite and metachert, metavolcanic rocks, side, D, downthrown side; arrows indicate relative Rn -Nikolai Greenstone. Numerous native Cu, Ni----- Chalcopyrite Cu----and marble interbeds. Also dikes and sills of gabbro Basaltic Cu----- Disseminated Slightly metamorphosed copper occurrences. sequence of massive basalt Postulated position of fault prior to intrusion lows and subordinate basaltic andesitic subvolcanic intrusive rocks of plutonic and subvolcanic rocks stratabound Co tuffs and breccias, some on South Fork of Pass (Late Cretaceous)--Hornblende andesite volcanic clastic rocks, and a Anticline-- Showing direction of plunge overlying sedfew limestone interbeds Flysch sequence (Early Cretaceous and Late Jurassic)-Tws -Metabasalt, metavolcani Graywacke turbidite, shale, siltstone, and conglomerate Overturned anticline-Showing direction of dip metasedimemtary rocks. Metamorphosed in southeast part of area. of limbs and plunge PPv-Slightly metamorphosed Overthrust flysch-like rocks (Early Cretaceous and Syncline--Showing direction of plunge. Dashed andesitic volcanic rocks. Late Jurassic)--Lithology identical to unit KJf where inferred Overturned syncline--Showing direction of dip onglomerate, sandstone, siltsone, shale, and volcanic rocks (Early Cretaceous and Late Jurassic)

MINERAL RESOURCE ASSESSMENT MAP OF THE HEALY QUADRANGLE, ALASKA

Dennis P. Cox, Thomas D. Light, Béla Csejtey, Jr., and David L. Campbell With a section on PLACER GOLD IN THE HEALY QUADRANGLE by Warren Yeend